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A CATAPULT FOR LAUNCHING A FLYING BODY

The invention relates to a catapult for launching a flying body.

US Patent US-A-4-909 458 discloses a catapult for launching a flying body, such as an unmanned aircraft of small size that serves as a target or that can perform reconnaissance missions, that catapult comprising:

- a rectilinear ramp that is inclined upwards;
- a carriage mounted to move on said ramp and adapted to carry said flying body;
- a winch on which a link is wound whose free end is attached to said carriage;
- at least one hydraulic motor disposed under said ramp and coupled to said winch; and
- at least one pressurized hydraulic fluid accumulator for feeding said hydraulic motor;

said ramp being subdivided into an acceleration zone, along which said carriage carrying said flying body is accelerated until said body reaches its liftoff speed, and a braking zone that extends said acceleration zone upwards and along which said carriage, free of said flying body, is braked until it stops.

Such a hydraulic catapult offers numerous advantages over known mechanical or pneumatic catapults, in particular because it implements excellent hydraulic motor speed, acceleration, and deceleration properties, without requiring complicated mechanisms, e.g. stroke amplifiers.

In the particular example described in US Patent US-A-4 909 458, the winch is disposed in the vicinity of the boundary between the acceleration zone and the braking zone of the ramp, and the link is in direct traction between the winch and the carriage. Thus, when the carriage crosses that boundary, it exerts traction on said link and constrains the winch to change its rotation direction. As a result, the hydraulic motor then

operates as a pump, which enables that carriage to be braked until it stops.

That known example thus makes it possible, in addition, to make advantageous use of the reversibility of the motor operation/pump operation of the hydraulic motors to brake the carriage.

Unfortunately, it must be observed that that known example suffers from drawbacks. Firstly, during the braking phase, the carriage, which has high inertia, is braked by the winch-and-hydraulic-motor assembly via the link, which is thus subjected to high traction stresses that can cause it to break or, at least, to wear quickly. In addition, the sudden reversal of the rotation direction, combined with those high traction stresses, raises difficulties in winding and unwinding the link on the winch, so that the turns of said link overlap, bulk up and/or become entangled. The result is then either that the link breaks or that lengthy operations are necessary for untangling it.

An object of the present invention is to remedy those drawbacks.

To this end, according to the invention, the catapult of the above-defined type is remarkable in that:

- said winch is disposed under the acceleration zone of said ramp;
- a transmission pulley over which said link passes is disposed under the braking zone of said ramp; and
- an energy-absorbing braking device is provided on said braking zone of the said ramp.

Thus by means of the present invention:

- it is no longer the winch-and-hydraulic-motor assembly that brakes the carriage, but rather it is the carriage that brakes said assembly (which has relatively low inertia) via said link; the link is thus subjected to much lower traction stresses;

- the link is no longer in direct traction between the winch and the carriage, but rather it forms a loop around said transmission pulley;

- the hydraulic motor always rotates in the same direction; and

- it is possible to choose the appropriate distance between the transmission pulley and the winch so that the turns of the link wind evenly and contiguously.

In a preferred embodiment of the invention, said brake device is of the type having elastomer material damping, and, to this end, it comprises a plurality of successive energy absorption stages that are constituted by elastic abutments made of elastomer and associated with support plates, and that are arranged in parallel manner on the braking zone of said ramp. The use of such a type of braking makes it possible to take up decelerations that are large and that are sufficient to stop the carriage in full safety, and also guarantees low inertia, insensitivity to climatic conditions, and advantageous compactness both in the length direction, so as not to make the length of the ramp overly long, and also in the height direction, so as not to hinder takeoff of the flying body.

In particular, said successive stages are mounted to slide on two guides that are disposed in mutually parallel manner on either side of the braking zone of the ramp, the first ends of said guides, which ends face said carriage, being supported by brackets secured to the ramp, while the second ends, situated in the vicinity of the top of the ramp, are engaged in the plate of said last stage, which plate is mounted in stationary manner on said ramp.

For example, said plurality of stages comprises first stages, each of which has one elastic abutment, arranged in the longitudinal midplane of the ramp, and last stages, each of which has two elastic abutments, disposed side-by-side and symmetrically on either side of

said longitudinal midplane of the ramp. Advantageously, each of the first two successive plates of the brake device, facing said carriage, is provided, in a manner inverted relative to each other, firstly with a cylindrical hole co-operating with one of the guides, and secondly with an oblong notch opening out in one side and co-operating with the other guide. Although this freedom of movement of the plates is limited, it self-centers the elastic abutments in the longitudinal midplane of the ramp, in particular when the contact between the carriage and the brake device does not take place in exactly aligned manner, thereby preventing the plates and the elastic abutments from jamming around the guides on braking (when the carriage comes into contact with the braking device), and therefore guaranteeing effective braking of the carriage and of the winch by compression of the abutments.

In addition, in order to further optimize the braking, at the front of said carriage, an elastic abutment made of elastomer is provided that forms a damper buffer and that comes into contact with said brake device for braking the carriage.

Furthermore, said transmission pulley is mounted in the vicinity of the end of the ramp, in the longitudinal midplane thereof, thereby making it possible to optimize and to choose as well as possible the distance between the pulley and the winch so as to enable the turns of the link to be wound evenly and contiguously while the carriage is moving on the ramp.

Preferably, two assemblies each comprising a hydraulic accumulator and a hydraulic motor are provided for driving the winding drum of the winch in rotation, said assemblies being disposed on a chassis on either side of and under said ramp carried by said chassis.

In addition, said chassis is provided with controllable hydraulic jacks for bringing it level and holding it stable.

According to another characteristic of the invention, said ramp is provided with a hinge at its acceleration zone, enabling it to take up a deployed, aligned, in-use position for launching said flying body, and a folded position for being transported and/or stored.

The figures of the accompanying drawings enable the manner in which the invention can be implemented to be well understood. In the figures, identical references designate like elements, and:

Figure 1 is a plan view of an embodiment of a catapult of the invention, in the position for launching a flying body;

Figure 2 is a larger-scale view of the carriage situated at the start of the ramp of said catapult shown in Figure 1;

Figure 3 is a larger-scale view of the brake device situated at the end of the ramp of said catapult;

Figure 4 is a view from above of the brake device of Figure 3;

Figures 5 and 6 are plan views of the first two plates of the brake device;

Figures 7 and 8 are cross-section views of the catapult, showing the two hydraulic accumulators and hydraulic motors coupled to the winch; and

Figure 9 shows how said ramp is hinged.

The catapult 1 shown in Figure 1 is designed to launch a flying body 2 such as a drone or the like.

In common manner, it comprises a rectilinear launching ramp 3 that is inclined upwards, a carriage 4 mounted to move on the ramp and carrying the flying body 2 and, in this type of catapult, a winch 5 to the drum 6 of which one end 7A of a link 7 is fastened, the free, opposite, other end 7B of said link being attached to the carriage 4. In order to accelerate the carriage carrying the flying body 2 along an acceleration zone ZA of the ramp until said carriage reaches the desired takeoff

speed of the body 2, the catapult 1 uses hydraulic energy for the reasons mentioned above and, for this purpose, is provided with suitable equipment having a hydraulic accumulator 8 and a hydraulic motor 9, as explained below, that rotates the drum, pulls and winds the link 7 therearound, and, as a result, moves the carriage 4 along the ramp. Then, in order to brake the carriage, once it is free of the flying body, over a braking zone ZF of the ramp 3 that extends the acceleration zone upwards, the catapult of the invention makes provision for a brake device 10 acting by energy absorption to be situated at the top of or at the end of the ramp, and to define the braking zone ZF.

In Figure 1, the catapult 1 is shown in its launching position, the carriage 4 that is carrying the flying body being situated at the bottom of or at the start of the ramp. In this example, the ramp 3 is supported by the chassis 11 of a trailer 12, but naturally it could be arranged directly on a platform of a vehicle or on a stationary station.

In accordance with the invention, the drum 6 of the winch 5 is disposed on the chassis 11 of the trailer, advantageously under the acceleration zone ZA of the ramp, and a transmission or deflector pulley 14 over which the link 7 passes is disposed under the braking zone ZF of the ramp, more particularly in the vicinity of the finish end thereof, by being mounted about an axis 15 associated perpendicularly with the ramp. The drum 6 and the pulley 14 are also arranged in the longitudinal (vertical) midplane PL of the ramp. Since the drum 6 is situated under the acceleration zone of the ramp and since the pulley is arranged at the top of the ramp under the braking zone, the link 7 forms a loop around the transmission pulley 14 and is thus no longer in direct traction between the drum and the carriage, as it is in the above-mentioned prior art example. In addition, the distance D between the axis 15 of the pulley and the axis

of the winch 5 can be optimized and chosen so that the turns of the link 7 wind evenly and contiguously around the drum 6 of the winch during the launching phase for launching the flying body, avoiding the risks of the link becoming entangled around the drum.

Structurally, the ramp 3 is mainly made from a rectangular hollow shaped-section member on which two longitudinal and parallel rails 16 for guiding the carriage are mounted on respective sides of the midplane PL. A hydraulic trigger mechanism 17 is provided at the start of the ramp (i.e. at the bottom) and serves to hold the carriage 4 in position, so as to release it when the catapult 1 is actuated, i.e. when the hydraulic equipment is actuated. At the end or finish of the ramp (i.e. at the top), the brake device 10 is situated. That device is described at a later stage below.

As shown in Figure 2, the carriage that serves as an interface between the ramp 3 and the flying body 2 has: an anchoring mechanism 18 on its top face 4A for the purpose of anchoring the flying body; rolling members 19 (wheels) on its bottom face 4B, which members co-operate with the rails 16 of the ramp; and a pin 20 on which the free end 7B of the link 7 is hooked. For example, the link is constituted by a cable, preferably made of resin-impregnated fibers of the Kevlar (registered trademark) type, which, in addition to imparting high strength to it, gives it a low mass, and thus a high inertia, during the acceleration phase, a certain amount of flexibility between the carriage and the winch in the braking phase, and insensitivity to atmospheric conditions and to the surrounding environment.

In addition, at the front of the carriage, a damper buffer is arranged that is constituted by an elastic abutment 21 made of an elastomer material and mounted on a plate 22 that is secured to or integral with the carriage. Said damper buffer protects the carriage when

it comes into contact with the brake device and thus also participates in the braking proper.

For the purpose of braking and of stopping the carriage 4 and the drum 6 of the winch, which drum is linked mechanically to the carriage via the link 7, after the flying body 2 has been launched, the energy-absorption brake device 10 uses elastic abutments made of elastomer material having high damping power and of the same type as the abutment provided at the front of the carriage.

As shown in Figures 3 and 4, the brake device 10 comprises a plurality of successive stages of elastic abutments 23 and of plates 24 supporting the abutments and alternating therewith. In this embodiment, five successive stages E1 to E5 are provided, and they are disposed one after another, parallel to one another, and along the axis of the ramp 3, along the braking zone ZF. The first two stages E1, E2 of the device are identical, and each of them is constituted by an elastic abutment 23 disposed in the longitudinal midplane PL of the ramp, and the last three stages E3, E4, and E5 of the device are identical, each of them being constituted by two elastic abutments 23 disposed side-by-side in parallel, on respective sides of the midplane PL of the ramp. The plates 24 are disposed between the abutments of each stage and they hold them in position by screw-fastening or by some other means.

The brake device 10 is secured to the ramp via two cylindrical guides 25 that are parallel to the ramp and that are disposed on either side thereof. More particularly, the successive stages are mounted to slide along said cylindrical guides, whose first ends 25A, facing towards the carriage, are secured to the ramp via fastening brackets 26, while the second ends 25B, situated in the vicinity of the top of the ramp, are engaged in the plate 24 of the last stage E5 of the brake device, which plate is fastened to the ramp.

Figure 4 shows that the guides 25 pass successively through the plates 24 of the first two stages E1, E2, and then through the plates 24 and the abutments 23 of the last three stages E3 to E5. The elastic abutments 23 of the various stages can then participate actively in braking the carriage by successively compressing along the guides, against the stationary retaining plate 24 of the last stage.

Springs 27 are also provided about the cylindrical guides between the fastening brackets and the first moving plate, and at the stationary plate and at the moving abutment of the last stage, in order to damp the return of the elastic abutments to their initial positions.

In addition, in order to guarantee optimum compression of the stages and thus maximum effectiveness of the brake device, along the axis of the ramp, even if the carriage 4 comes into slightly misaligned contact with the brake device 10, the first two plates 24 of the brake device have a certain amount of freedom of movement relative to the guides. For this purpose, as shown in Figure 5, the first plate 24.1 is, on one side, provided with a circular hole 28 for mounting the corresponding cylindrical guide 25, while, on the other side, it is provided with an oblong notch 29 opening out in its side edge 24.1A and through which the other guide 25 passes. Thus, the plate can move angularly slightly around the coupling between the circular hole 28 and the guide 25, by means of the oblong notch. The same applies for the second plate 24.2 shown in Figure 6 but whose circular hole 28 and whose oblong notch 29 opening out in the side edge 24A, 2A co-operate with respective ones of the other cylindrical guides.

Although this freedom of movement of the two plates is limited, it makes it possible to correct any angular offset of the carriage that might occur during the launching phase, relative to the brake device that is

aligned on the ramp, and to self-center the action of the elastic abutments along the axis of the ramp, thereby avoiding any risks of the stages jamming on the guides during compression of the abutments and thus avoiding loss of effectiveness of the brake device.

During the stopping of the carriage, each of the last three two-abutment stages takes up a braking force that is higher than the first two stages, each of which is equipped with a single abutment.

It is the carriage itself that, via the link, brakes itself on the ramp, thereby braking the drum, via the elastic abutments of the brake device, so that the link is subjected to reduced and quite acceptable traction stresses.

As shown, in particular, in Figures 7 and 8, the equipment for launching the flying body 2 is advantageously made up of two fluid accumulators with which two hydraulic motors coupled to the winch are respectively associated. More particularly, the two identical accumulators 8 are of the diaphragm type and are arranged on either side of the ramp 3, on supports 30 that are hinged to the chassis 11. The two hydraulic motors 9, in communication with the accumulators, are disposed in stationary manner on either side of a casing 31 of the winch that is secured to the chassis. The outlet shafts 9A of the hydraulic motors pass through the side faces 31A of the casing and are coupled in mutual alignment to the drum, via suitable drive mechanisms 32. The accumulators feed the hydraulic motors with pressurized fluid via flow-rate limiters 33, and a hydraulic reservoir 34 is also in communication with the motors and is fastened to the chassis in the vicinity of and above the motors so as to avoid head loss and any accidental air intake into the hydraulic circuit, as shown in Figure 1.

The drum 6 of the winch 5 is, for example made of aluminum, which gives it low inertia in rotation, and its

diametrical midplane (Figure 8) lies in the longitudinal midplane PL of the ramp.

As regards the chassis 11 of the trailer shown in Figure 1, it is of the tubular type and is equipped, in particular, with four hydraulic jacks 35 controlled by actuators 36 and serving to bring the catapult level and to hold it stationary. A hydraulic jack 37 is also provided under the ramp, in the vicinity of its lower portion.

In addition, an energy generator set, constituted by an engine 38 and by a hydraulic pump 39 coupled to said engine and in communication with the reservoir 34, is mounted on the chassis 11, under the ramp, and makes it possible to power the various hydraulic components provided on the catapult. Two cabinets 40 and 41 are provided on the chassis for containing the various control and monitoring means for controlling the components and for ensuring that the catapult is operating properly. The cabinet 40 controls hydraulic distribution and contains the electrically-driven distributors, valves, filters, etc. making it possible, in particular, to fill and to empty the accumulators, to control the trigger mechanisms, etc., and the cabinet 41 controls electrical distribution and automatic logic control, such as the catapulting pressure, the positions of the trigger and of the carriage, the catapulting orders, inflation/deflation of the accumulators, etc.

According to another characteristic of the catapult, the ramp 3 is foldable so as to reduces its external size for transport or storage purposes. For this purpose, as shown in Figures 1 and 9, it is provided, in its acceleration zone, with a hinge 42 of the type having a cylindrical hinge pin. This hinge subdivides the ramp 3 into two portions 3A, 3B and enables it to take up a deployed operating position in which the two portions 3A, 3B are in alignment, the hinge plates 42A, 42B secured to respective ones of the portions being fastened together

by eyebolts 42C, and a folded position shown in dashed lines in Figure 9 and in which the portion 3B is folded over parallel to the portion 3A by pivoting about the hinge pin 42D and by the bolts being tilted.

A brief description follows of how the catapult launches the flying body.

The pressurized fluid stored in the two accumulators 8 is sent into the hydraulic motors 9 whose outlet shafts 9A, which are then driven in rotation, cause the drum 6 to rotate at the desired speed. After the trigger mechanism 17 has retracted, the link 7 winds around the drum, via the pulley 14, and pulls the carriage 4 carrying the flying body along the ramp 3. When the carriage reaches the end of the acceleration zone ZA of the ramp, the flying body, having acquired sufficient velocity, is released from the carriage and takes off to perform its mission. The carriage 4 then hits the brake device 10, whose elastomer abutments 23 compress successively and slide along the guides so as to absorb the energy and so as to brake and then stop the carriage 4, and the drum 6, via the link 7. During the launching and braking phases, the drum always rotates in the same direction.

After re-inflating the accumulators and putting the carriage back into its initial position (Figure 1), another launch can be scheduled.

CLAIMS

1. A catapult for launching a flying body, such as an aircraft of small size, said catapult being of the type comprising:

- a rectilinear ramp (3) that is inclined upwards;
- a carriage (4) mounted to move on said ramp and adapted to carry said flying body;
- a winch (5) on which a link (7) is wound whose free end is attached to said carriage;
- at least one hydraulic motor (9) disposed under said ramp and coupled to said winch; and
- at least one pressurized hydraulic fluid accumulator (8) for feeding said hydraulic motor;

said ramp being subdivided into an acceleration zone (ZA), along which said carriage carrying said flying body is accelerated until said body reaches its liftoff speed, and a braking zone (ZF) that extends said acceleration zone upwards and along which said carriage, free of said flying body, is braked until it stops;

said catapult being characterized in that:

- said winch (5) is disposed under the acceleration zone (ZA) of said ramp;
- a transmission pulley (14) over which said link passes is disposed under the braking zone (ZF) of said ramp; and
- an energy-absorbing braking device (10) is provided on said braking zone (ZF) of the said ramp.

2. A catapult according to claim 1, characterized in that said brake device (10) is of the type having elastomer material damping, and in that it comprises a plurality of successive energy absorption stages that are constituted by elastic abutments (23) made of elastomer and associated with support plates (24), and that are arranged in parallel manner on the braking zone (ZF) of said ramp (3).

3. A catapult according to claim 2, characterized in that said successive stages (E1-E5) are mounted to slide on two guides (25) that are disposed in mutually parallel manner on either side of the braking zone of the ramp, the first ends (25A) of said guides, which ends face said carriage, being supported by brackets secured to the ramp (3), while the second ends (25B), situated in the vicinity of the top of the ramp, are engaged in the plate (24) of said last stage (E5), which plate is mounted in stationary manner on said ramp.

4. A catapult according to claim 2 or claim 3, characterized in that said plurality of stages comprise first stages (E1, E2), each of which has one elastic abutment, arranged in the longitudinal midplane (PL) of the ramp (3), and last stages (E3, E4, E5), each of which has two elastic abutments, disposed side-by-side and symmetrically on either side of said longitudinal midplane of the ramp.

5. A catapult according to any one of claims 2 to 4, characterized in that each of the first two successive plates (24.1 - 24.2) of the brake device (10), facing said carriage, is provided, in a manner inverted relative to each other, firstly with a cylindrical hole (28) co-operating with one of the guides, and secondly with an oblong notch (29) opening out in one side and co-operating with the other guide.

6. A catapult according to any preceding claim, characterized in that, at the front of said carriage (4), an elastic abutment (21) made of elastomer is provided that forms a damper buffer and that comes into contact with said brake device (10) for braking the carriage.

7. A catapult according to any one of claims 1 to 6, characterized in that said transmission pulley (14) is

mounted in the vicinity of the end of the ramp (3), in the longitudinal midplane thereof.

8. A catapult according to any one of claims 1 to 7, characterized in that two assemblies each comprising a hydraulic accumulator (8) and a hydraulic motor (9) are provided for driving the winding drum (6) of the winch (5) in rotation, said assemblies being disposed on a chassis (11) on either side of and under said ramp carried by said chassis.

9. A catapult according to claim 8, characterized in that said chassis (11) is provided with controllable hydraulic jacks (35) for bringing it level and holding it stable.

10. A catapult according to any preceding claim, characterized in that said ramp (3) is provided with a hinge (42) at its acceleration zone, enabling it to take up a deployed, aligned, in-use position for launching said flying body, and a folded position for being transported and/or stored.

ABSTRACT

The invention relates to a catapult for launching a flying body (2) carried by a carriage (4). According to the invention, said catapult is remarkable in that: a winch (5) coupled to an assembly comprising a hydraulic accumulator and a hydraulic motor (9), is disposed under the acceleration zone (ZA) of said ramp; a transmission pulley (14) over which a link (7) that is wound on the winch (5) and that is attached to the carriage (4) passes is disposed under the braking zone (ZF) of said ramp; and an energy-absorbing braking device (10) is provided on said braking zone (ZF) of the said ramp.